Financial assessment of oil palm cultivation on peatland in Selangor, Malaysia

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SUMMARY

Oil palm plantations on peat soils are generally believed to have greater environmental impacts than those on other soil types. Nonetheless, Malaysia operates substantial incentives to maximise palm oil production, which in practice encourage the establishment of plantations on peatland. This paper explores the social and economic basis of oil palm cultivation on one peatland estate at Sungai Panjang in the state of Selangor, peninsular Malaysia. Data were obtained by conducting a questionnaire survey of 200 farmers who cultivate oil palm on peat soil. Some of the data were cross-tabulated against farmers' ages in order to identify any age-related trends in education level, the area of land farmed, annual income and knowledge about oil palm cultivation. The Cobb-Douglas production function was used to model the financial output from oil palm in terms of the costs of chemical inputs and labour. The results indicated that cultivation of this crop gives decreasing returns to scale on peatland in Sungai Panjang, and that chemical inputs are more important than labour cost in determining the level of financial output. Finally, the financial viability of oil palm cultivation for farmers was assessed by calculating three financial indicators (NPV, BCR and IRR). This can be a profitable investment so long as growth conditions, costs, selling price and interest rate do not fluctuate substantially. Greater annual returns can be achieved over 20–25 years than over shorter periods, especially of less than 10 years.

KEY WORDS: economic analysis, peninsular Malaysia, plantation forestry, Sungai Panjang.

INTRODUCTION

The area of peatland in south-east Asia is approximately 30 million hectares. Of this, 10% occurs in Malaysia, where it accounts for approximately 8% of the country's total land area. Most of the remainder is in Indonesia; although available information suggests that there may also be *ca*. 3 million ha of peatland in Papua New Guinea, and there are smaller areas in Thailand, Vietnam and the Philippines. More than half of Malaysia's peatland (*ca*. 1.7 million hectares) is located in the state of Sarawak (on Borneo), which is 13% peat-covered. The peatland in peninsular Malaysia is largely coastal, and the most peatland-rich state is Selangor Darul Ehsan (the Sultanate of Selangor) (Abdul Rahim 2007).

Palm oil is derived from the fruits of the African oil palm *Elaeis guineensis*, which was introduced to Malaysia in the early 20th century. The oil has long been used as a lubricant, for cooking, and in soap products (e.g. 'Palmolive'); and contributes significantly to the country's Gross Domestic Product (GDP). It has now found a new use as biofuel, and the recent dramatic increases in the price of petroleum have driven changes in government policy to encourage the production of palm oil as a replacement. This can be expected to increase the establishment of oil palm plantations on more marginal land such as peatland, where the trees require more fertiliser and are at greater risk from fire than on other types of land. Wider environmental concerns have also been expressed about such developments on tropical peatland (e.g. Butler 2007). In order to understand how to use the peatland wisely in this context (e.g. MARDI 2006), it is imperative to know the main determinants of revenue from oil palm plantations on peatland.

Many farmers and smallholders working peatland in peninsular Malaysia already choose to cultivate oil palm. One possible reason is that the financial return is higher than that from other crops such as pineapple (Yusof & Chan 2004). In this paper we report the results of a preliminary exploration of the social background and economics of oil palm cultivation on an example peatland area in Selangor.

METHODS

Site and data collection

Our study focused on a single estate, namely Sungai Panjang, which is located in the administrative district of Sungai Besar (3° 40' 0" North, 100° 59' 0" East; Figure 1), and has extensive oil palm plantations on peatland. The primary data were collected from 200 farmers who cultivate oil palm, using survey type research with a cross-sectional design. The survey involved completing a questionnaire covering environmental and financial aspects of oil palm cultivation (Appendix 1) during a face-to-face interview with each farmer. The social backgrounds of the farmers and their attitudes to oil palm cultivation were explored by empirical analysis and cross tabulation of questionnaire data.

Cobb-Douglas model

The Cobb-Douglas production function (Cobb & Douglas 1928) was used to model the relationship between input factors and the total (monetary) output derived from oil palm by the 200 farmers. Capital was not included as an input because, in this case, it would be proxied by the value of fixed assets that have no significant effect on the annual production of fruit once the plantation has been established. The main factors influencing the annual production of fruit are the inputs of chemicals and labour. Thus, the stochastic form of the equation formulated was:

$$Q = k\ CI^{\alpha} L^{\beta} \quad [1]$$

where Q (output) represents the total annual earnings of each farmer from oil palm cultivation, calculated from the area of land under oil palm, the annual yield of oil palm fruit and the current selling price; CI (chemical input) is the total cost of fertiliser, insecticide and herbicide; L is the total annual cost of labour; and k, α and β are positive constants. Transforming to natural log form, we obtain the linear regression model:

$$\ln Q = \ln k + \alpha \ln CI + \beta \ln L + \mu \quad [2]$$

The properties of the Cobb-Douglas production function are well known (Gujarati 2003). The constants α and β are the output elasticities of CI and L respectively, and indicate how Q would respond to a unit change in CI or L if the other was unchanged. Thus, for example, if β = 0.15, a 1%

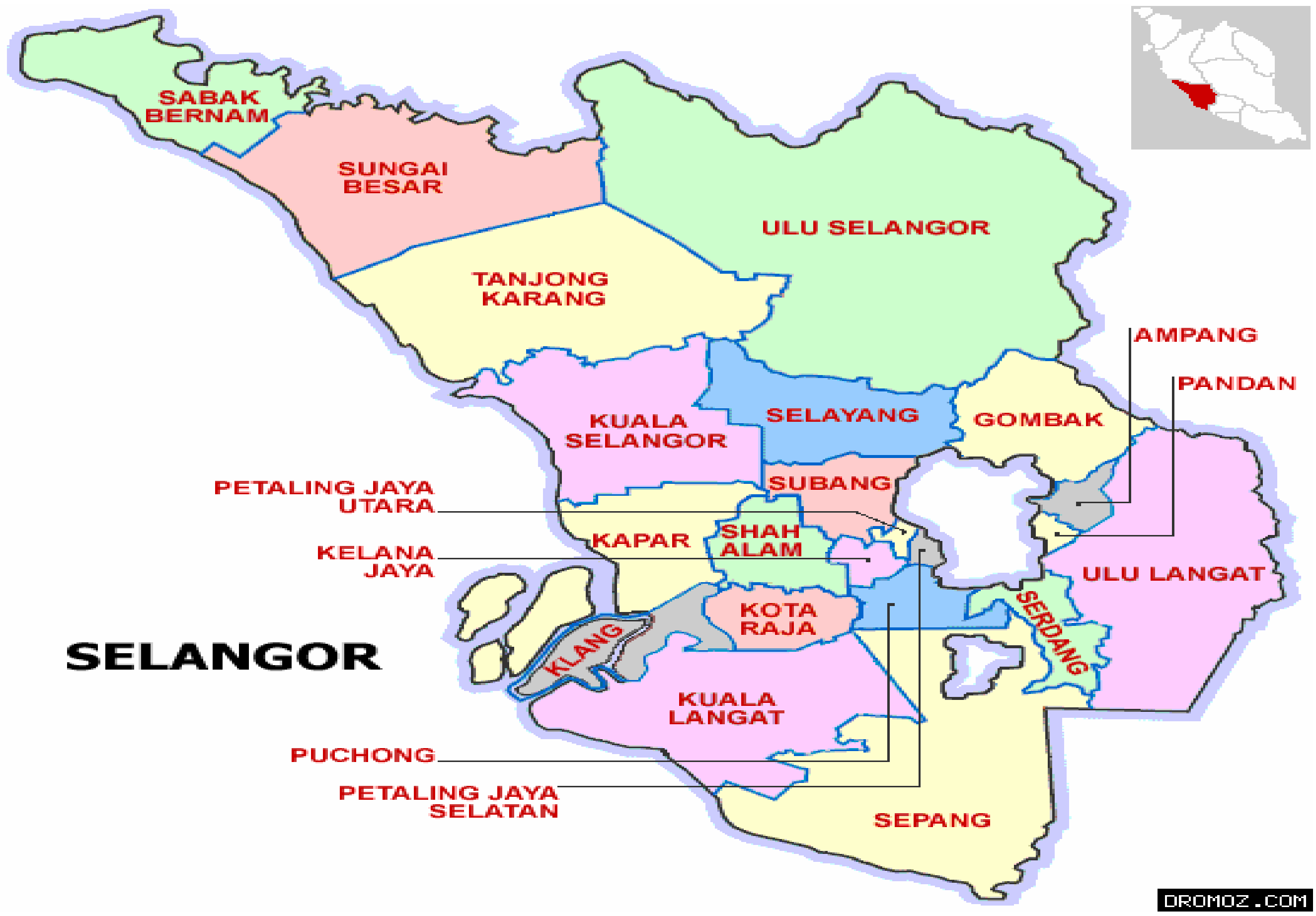


Figure 1. Administrative districts of the State of Selangor, which is located on the western side of peninsular Malaysia (inset). From Dromoz (2009).

increase in labour costs would lead to a 0.15% increase in output, *ceteris paribus*. If the sum ($\alpha + \beta$) is equal to unity, the production function has constant returns to scale, i.e. altering the inputs will give rise to proportional changes in output such that doubling the inputs will double the output, tripling the inputs will triple the output, *etc*. If ($\alpha + \beta$) < 1, there are decreasing returns to scale, and doubling the inputs will give less than double the output; whereas if ($\alpha + \beta$) > 1, there are increasing returns to scale, and doubling the inputs will more than double the output. The constant μ is an error term, also termed the stochastic disturbance term or residual, which encapsulates changes that cannot be explained by the model. Combining the constant terms and substituting $K = (\ln k + \mu)$, Equation 2 becomes

$$\ln Q = K + \alpha \ln CI + \beta \ln L \qquad [3]$$

The 200 responses to Questions 6 (earnings) and 9 (inputs of chemicals and labour) of the farmers' questionnaire were used to calculate total earnings and inputs for substitution in Equation 3. The values of the coefficients K, α and β were then estimated by minimising the Residual Sum of Squares using the Ordinary Least Squares (OLS) method provided by the software package EViews 6 (QMS 2009).

OLS is, essentially, the standard linear regression procedure. Several assumptions must generally be fulfilled for such a Classical Linear Regression Model (CLRM) (Gujarati 2003). As some of them may be altered by regressing the model, their validity must be re-checked at this stage. The OLS estimators k, α, and β in the model are linear functions of μ_I and thus pass the normality test because any linear function of normally distributed variables is itself normally distributed ($u_i \sim N(0, \sigma^2)$; i.e. the error term is normally distributed with zero mean and constant variance. The additional problem of heteroscedasticity is usually associated with cross-sectional data rather than time series data, and arises when the error term E has unequal variance (symbolically $E\ (u^2_i) = \sigma^2_i$ where the subscript of σ^2 reminds us that the conditional variances, and thus the variance of Q, are no longer constant).

Financial assessments

In this study we estimated the financial return of oil palm cultivation on peatland, and we did not include any externalities; in other words, we were concerned with financial aspects (i.e. farmers' income) only. We used primary data, derived from the farmers' responses to Section III of the questionnaire (see Appendix). Financial performance was evaluated in terms of Net Present Value (NPV), Benefit-Cost Ratio (BCR) and Internal Rate of Return (IRR) over a period of 25 years. The study was conducted in an *ex-ante* setting, i.e. we estimated what a smallholder farmer would gain from oil palm cultivation on peat soil, all other things being equal.

The costs of production taken into account were establishment costs, input costs and labour costs. Establishment costs are incurred during the first year of planting and include clearing and preparation of the land, drainage (needed for peat soil), construction of roads, setting out rows, holing and planting. The planting areas that are developed are generally much larger than an individual farmer's land holding. Soil compaction is not usually carried out overtly because it occurs during clearing of forest by heavy machinery (MPOB 2002). The chemical input costs include planting materials, fertilisers, herbicides and pesticides. Since the planting density for oil palm is only 160 palms ha^{-1}, modest fertiliser applications are required and this influences the total annual cost to the farmer. Labour costs are incurred in fertilising, pruning, weeding, harvesting and transportation.

The yield depends on the maturity of the palm. Oil palm will normally start reproducing three years after planting, so that the first fruits are borne in the fourth year. At a density of 160 palms ha^{-1}, yield can be up to 17 tonne ha^{-1} (of fruit bunches) during the first year of harvest and up to 30 tonne ha^{-1} during the fifth year of harvest (Tayeb 2005). Subsequent harvests average 25–28 tonne ha^{-1}, declining after the fifteenth year. However, these are estimates, and yield can be affected by many factors such as the incidence of pests, unusual periods of drought, and prolonged heavy rain or haze.

The profit level is influenced by planting density, yield and market price. For peat soil, it has been shown that increasing the planting density has a positive impact on the fresh fruit bunch (FFB) yield up to a density of at least 200 palms ha^{-1}, but the planting density that is used in practice is 160 palms ha^{-1} (Jusoh *et al*. 2003). The market price of this crop fluctuates but the FFB price has recently been increasing steadily and by mid-2007 it had reached 500 Malaysian Ringgit (RM 500, equivalent to *ca*. 100 euro) tonne^{-1}. The market price used in this study is RM 530 tonne^{-1}, which was the price when the survey was conducted in December 2007.

Other data required for the calculations were the discount rate (which reflects the change in value of money with time and is equal to the long-term interest rate) and the project life (number of years for discounting) (Jusoh *et al*. 2003). In attaching values to the inputs and outputs, constant prices were assumed. The discounted sum of total revenue (also known as the present value of benefit) and the discounted sum of total cost (present value of cost) were calculated annually over 25 years using an interest rate of 4%.

Net Present Value

The Net Present Value (NPV) is a single computed number that indicates the overall financial performance of a project or programme. Annual income and returns are first estimated as in an ordinary cost-benefit analysis for the whole project period, and then discounted to present values. The total discounted income and costs are then calculated, and the excess of total income over total costs is the net present value of the project (Turner *et al*. 2000). The formula for calculating the NPV is:

$$NPV = \sum_{t=1}^{T}\sum_{i=1}^{n}\frac{B_{it}}{(1+r)^t} - \sum_{t=1}^{T}\sum_{j=1}^{m}\frac{C_{it}}{(1+r)^t} \quad [4]$$

where B is the annual benefit of the project, C is its annual cost, r is the discount rate (assuming that the market rate is equal to the shadow rate), n is the number of items that constitute the benefits, m is the number of items that make up the costs and T is the duration of the project in years. Implementation of the project is justified if NPV is positive, i.e. the development project will potentially create a net return (profit) to the investor. The magnitude of NPV simply indicates the magnitude of the profit expected.

Benefit-Cost Ratio

Benefit-Cost Ratio (BCR) is the benefit received per unit cost of the development project, and is thus an indicator of the efficiency of project investment. Thus, the BCR can be used to determine the most cost-efficient choice of development, enabling the private investor or public sector authority to justify whether or not, and where, the project should be implemented (Turner *et al*. 2000). The BCR is calculated as follows:

$$BCR = \frac{\sum_{t=1}^{T}\sum_{i=1}^{n}\frac{B_{it}}{(1+r)^t}}{\sum_{t=1}^{T}\sum_{j=1}^{m}\frac{C_{it}}{(1+r)^t}} \quad [5]$$

where all variables are as for Equation 4. If $BCR > 1$, the project is justified on economic grounds, and cost effectiveness increases with the value of BCR.

Internal Rate of Return

The internal rate of return (IRR) is an indicator of the efficiency or quality of an investment that is used by firms to decide whether they should make investments. It is the rate of return from the development project that would deliver an NPV equal to 0. The opportunity cost of investing funds in the project is the difference between the IRR and the interest rate on a comparable loan, the investment being justifiable when the IRR exceeds the loan rate. Theoretically speaking, the project is worth investment from the private viewpoint if the internal rate of return is higher than the market interest rate (Friedlob & Plewa 1996, Luenberger 1997, Meggison 1997, Hyder *et al*. 1999, Ahtikoski *et al*. 2008). The IRR can be calculated using the NPV formula, since it is simply the value of r that will return $NPV = 0$. All other terms, including annual benefit and cost values as well as time, are unaltered. Thus $IRR = r$ when:

$$NPV = \sum_{t=1}^{T}\sum_{i=1}^{n}\frac{B_{it}}{(1+r)^t} - \sum_{t=1}^{T}\sum_{j=1}^{m}\frac{C_{it}}{(1+r)^t} = 0 \quad [6]$$

In brief, the cost and benefit analysis methodology helps to justify the project or programme if it is found that NPV > 0 and IRR > loan rate.

Sensitivity analysis

The financial indicators provide convenient indices for assessing financial performance, but their disadvantage is that all of them are "static" through time. In the real world, factors that affect them vary. Particularly when these factors change in the pessimistic direction, the conclusions of the analysis in terms of viability of the project will no longer hold. Therefore, we have re-calculated the financial indicators using different values for the relevant inputs in order to explore how robust the financial performance of oil palm cultivation may prove to be under changing market circumstances. This process is known as sensitivity analysis (SA), and it enables us to estimate the financial risks associated with such developments.

The crucial factors that are likely to affect the financial indicators that we have calculated include, *inter alia*:

1. the market price of oil palm FFB, which affects the income derived from selling each year's crop in exactly the same way as changes in yield and planting density if expressed as percentages;
2. the costs of material inputs and labour; and
3. the long-term interest rate, which is influenced by shorter-term fluctuations of financial markets and for which a very different value from ours (10%) was adopted by Jusoh *et al*. (2007).

Sensitivity analysis involves evaluation of the financial indicators assuming defined percentage or absolute changes in the relevant inputs, considered singly. Reliability is improved if the potential changes tested are derived from trend analysis or model predictions. In this case, the analysis was carried out by re-calculating NPV, BCR and/or IRR for various assumed changes in the crucial factors listed above, for example a 10% increase in some or all of the project costs. Comparing the resulting changes in the values of the financial indicators gives insights into how sensitive the project is to changes in each of the factors.

RESULTS

Social background of farmers

The cross-tabulations of age with level of education, area of land holding and annual income are shown in Table 1. None of the 200 farmers was aged under 20 and the majority (117) were 41–60 years old. Twenty-one (*ca*. 10%) of them had never received formal education, more than half (105) had completed only primary school, around one-third (72) had continued into secondary education up to Form 3 or Form 5, and only two had been in tertiary education. The majority of interviewees aged 51–80 had completed primary education only, whereas a fairly constant proportion (>20%) of those aged 21–50 had been in secondary school until Form 3, and ‘under-40s’ had increasingly stayed on through Form 5. However, the results give little indication of any associated improvement in the area of land worked or in annual income. Most of the younger farmers worked 1.5 ha or less of land for an annual income of up to RM 10,000; nobody under 40 earned more than RM 20,000; and one person in the 31–40 age group earned less than RM 1,000. The circumstances of older (41–70-year-old) farmers were more varied, some having larger land holdings and higher incomes, whilst others had lower incomes than the modal group. Nonetheless, the modal size of land holding for all age groups up to 70 years was 1.1–1.5 ha and the modal income was RM 5,001–10,000. The single octogenarian, who had received no formal education, was farming more than 3.5 ha and had an annual income in excess of RM 30,000.

Almost 90% of the farmers interviewed had no knowledge of uses for parts of the oil palm plant such as the leaves, trunk, frond, shell and empty fruit bunch (EFB). Of the 23 who did have some knowledge, most (22) knew about using the leaves, almost half (11) about the fronds and around one-third (6 or 7) about the trunk or EFB. The sample was too small to deduce age-related trends, but only two farmers aged under 40 years knew about uses of the oil palm shell (Table 2). Nonetheless, oil palm was the main source of income for most farmers earning less than RM 25,000 p.a., who regarded this crop as essential for their survival. Farmers with higher incomes were not solely dependent on oil palm, but their answers to Question 14 of the questionnaire indicated that they believed they must maintain their plantations to provide vehicle fuel in case of petroleum shortages in the future.

Cobb-Douglas model

Table 3 illustrates the result of iteratively evaluating the model using the OLS method to give the best fit in terms of the highest value of (adjusted R^2) that could be achieved. All three coefficients have positive values, and the values of t-statistics for both independent variables indicate that the coefficients are statistically valid. Thus, Equation 3 becomes:

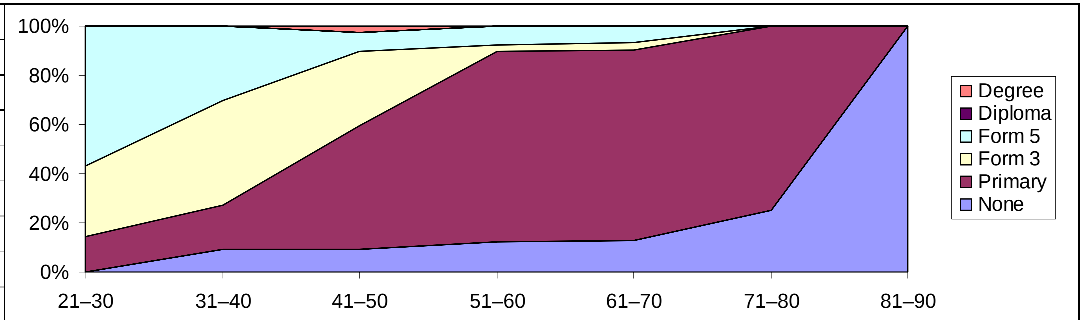
$$\ln Q = 4.481 + 0.700^{***} \ln CI + 0.046^{***} \ln L \quad [7]$$

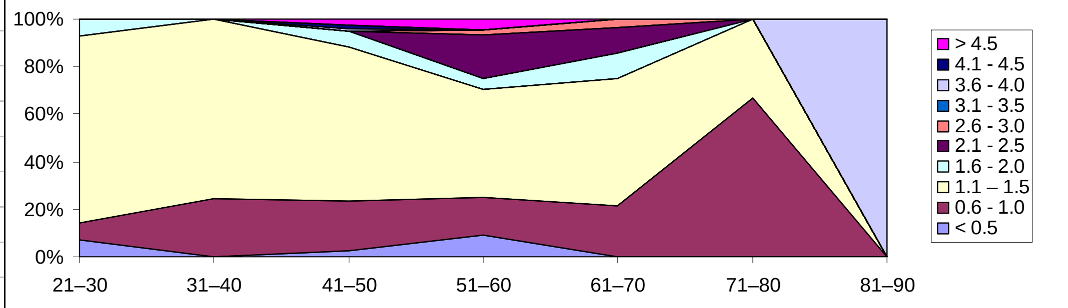
where *** indicates significance at the 1% level. The constant (intercept term), as usual, gives the mean or average effect on the dependent variable of all the variables that are not included in the model (Elsadig 2008a, 2008b, 2008c).

Before proceeding, we test the null hypothesis that α or $\beta = 0$ (No Significant Relationship), which can be rejected because the t-statistics for α and β exceed the 1% critical value (T-critical 1%) of 1.99. Thus, the costs of both chemical inputs CI and labour L (the exogenous variables) are statistically significant determinants of output Q (the endogenous variable). A 1% change in CI will lead to a change of 0.7% in Q if L is unchanged, whilst a 1% change in L will lead to a change of 0.046% in Q if CI remains constant. Both inputs have positive relationships with output, and the change in CI affects Q more than the same change in L. We also reject the null hypothesis that $\alpha = \beta = 0$ (No Significant Relationship) because the F-statistic is 62.13 with a p-value of zero (Table 4), and accept the alternative hypothesis that there is a significant relationship between each of the independent variables (CI and L) and the dependent variable (Q). We can now conclude that the model is valid. The R^2 value is a measure of the goodness of fit of the regression, indicating how well the independent variables explain the dependent variable. The value of 0.387 shown in Table 1 means that only 38.7% of the variation in Q is explained by the variation in CI and L, and the remaining 61.3% arises from our use of primary cross sectional data and many other factors that we did not consider in this study. Since heteroscedasticity is usually associated with cross-sectional data, we applied the Autoregressive Conditional Heteroscedasticity (ARCH) Test to our

Table 1. Cross-tabulation of educational level, area of land holding and annual income against age group for the sample of 200 farmers. The graph to the right of each table shows the percentage of farmers within each age group (horizontal axis) falling into each category.

	Age (years)	21–30	31–40	41–50	51–60	61–70	71–80	81–90	Totals
	Number	14	33	77	40	31	4	1	200
Education	Degree			2					2
	Diploma								0
	Form 5	8	10	6	3	2			29
	Form 3	4	14	23	1	1			43
	Primary	2	6	39	31	24	3		105
	None		3	7	5	4	1	1	21
Area of land holding (ha)	> 4.5			2	2				4
	4.1–4.5			1					1
	3.6–4.0			1				1	2
	3.1–3.5								0
	2.6–3.0				1	1			2
	2.1–2.5				8	3			11
	1.6–2.0	1		5	2	3			11
	1.1–1.5	11	25	50	20	15	1		122
	0.6–1.0	1	8	16	7	6	2		40
	< 0.5	1		2	4				7
Annual income (RM)	> 30,000			3	2	1		1	7
	25,00–30,000			2	1	1			4
	20,001–25,000			1	1				2
	15,001–20,000	2	2	2	4	2			12
	10,001–15,000	1	3	11	5	6			26
	5,001–10,000	10	24	46	18	13	2		113
	1,001–5,000	1	3	12	10	8	1		35
	< 1,000		1						1





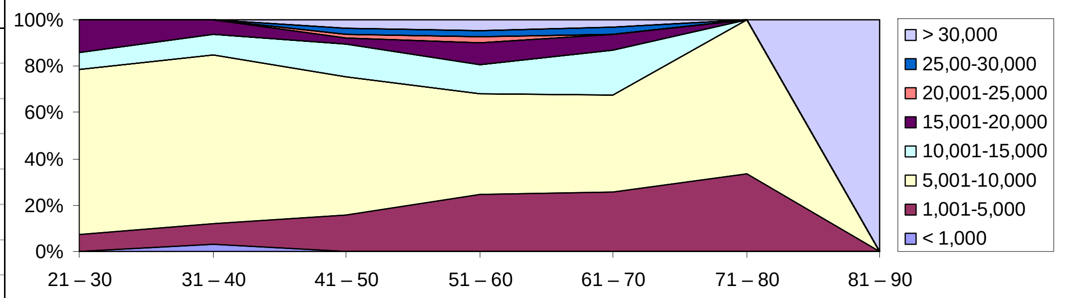


Table 2. Cross-tabulation of general and specific knowledge of the uses of oil palm parts (other than FFB) amongst the farmers interviewed. The left-hand part of the table shows the number of farmers in each age group who knew of uses for 0–5 additional parts of the tree. Only 23 of the 200 farmers knew uses for any additional parts; the number in each age group who knew about each of the other usable parts is shown in the right-hand part of the table.

age (years)	Number of parts for which uses known						informed farmers	Additional usable parts of oil palm				
	0	1	2	3	4	5		leaves	frond	trunk	EFB	shell
21–30	9	4			1		5	5	1		1	1
31–40	30	1	1	1			3	2	2	1		1
41–50	71	1	1	1	3		6	6	5	3	4	
51–60	38	1	1				2	2		1		
61–70	25	3	2	1			6	6	2	1	1	
71–80	3			1			1	1	1	1		
81–90	1						0					
TOTALS	177	10	5	4	4	0	23	22	11	7	6	2

Table 3. Results of fitting the empirical data to Equation 3 using the Ordinary Least Squares (OLS) method. The dependent variable is ln*Q* and the sample size (number of observations) is 200.

Variable	Coefficient	Standard Error	t-Statistic	Probability
ln*CI*	0.699546	0.067349	10.38680	0.0000
ln*L*	0.046042	0.012154	3.788221	0.0002
S	4.480721	0.438296	10.22306	0.0000

R-squared	0.386791	Mean dependent variable	9.107782
Adjusted R-squared	0.380566	S.D. dependent variable	0.678744
S.E. of regression	0.534200	Akaike info criterion	1.598793
Sum squared resid	56.21777	Schwarz criterion	1.648267
Log likelihood	-156.8793	F-statistic	62.13045
Durbin-Watson stat	1.732078	Probability (F-statistic)	0.000000

model. Table 4 shows that the p-value of the F-statistic is greater than the threshold value of 0.05, indicating that the heteroscedasticity problem is absent in this case.

Table 4: Results of Autoregressive Conditional Heteroscedasticity (ARCH) Test.

F-statistic	3.677677	Probability	0.056592
Obs*R-squared	3.646932	Probability	0.056173

The sum ($\alpha + \beta$) is equal to 0.746, i.e. less than unity. Therefore, the Cobb Douglas function indicates that the average farmer in Sungai Panjang experiences decreasing returns to scale, so that doubling chemical inputs and labour will increase the output Q by less than 100%.

Financial assessments

Figure 2 shows the pattern of annual costs and returns for oil palm production throughout the 25 years simulated, and Table 5 gives a detailed cashflow. Costs are highest in the first year because

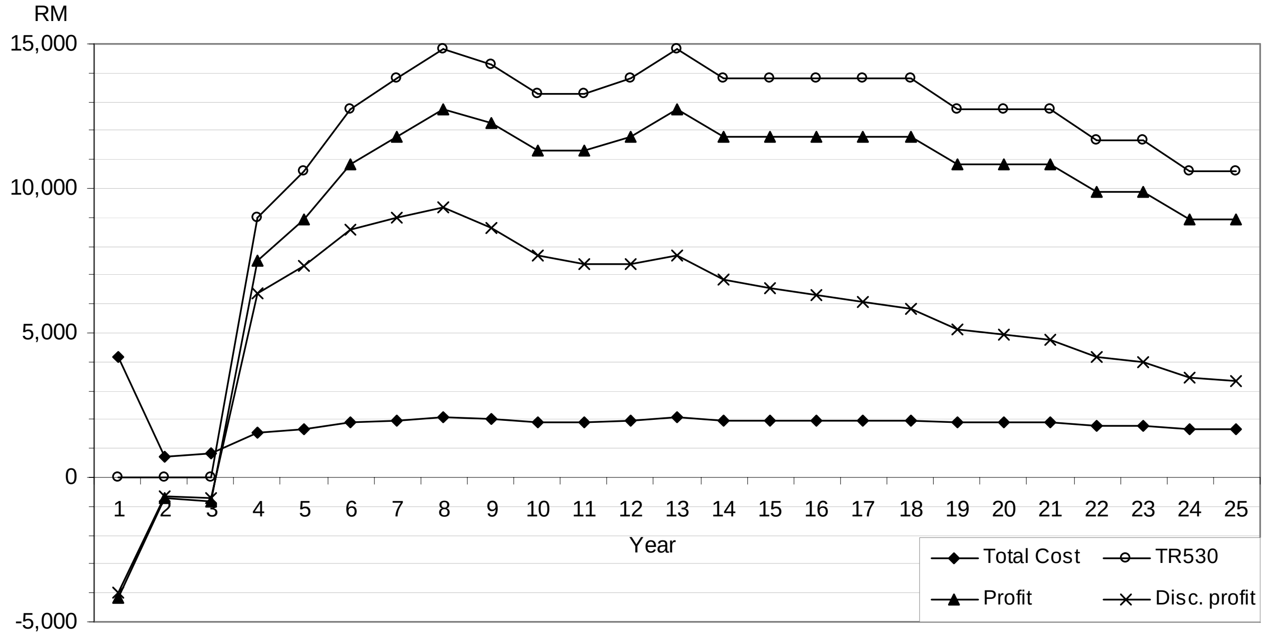


Figure 2. Estimated total annual cost, revenue (TR530), profit and discounted profit in Malaysian Ringgit (MR 5 ≈ €1) per hectare of oil palm production by 200 farmers in Sungai Panjang over a projected period of 25 years, for a scenario with market selling price MR 530 tonne^{-1} FFB and long-term interest rate 4% (see also Table 5).

of the massive establishment costs incurred in clearing, preparing and planting the land. They diminish dramatically in the second year, then increase gradually from Year 3 to Year 8 before stabilising as the annual yield of FFB stabilises. There is no revenue during the first three years because the immature trees are not yet producing fruit. Revenue starts to climb steeply during the fourth year, when the trees mature and begin to produce fruit, and continues to increase because the yield of FFB from young trees increases annually until the eighth year. In the following years, income begins to fluctuate but remains fairly stable until Year 18, after which it begins to decline due to the age of the (over-mature) trees.

Applying the interest rate of 4%, the discounted sum of total revenue is RM 164,944 and the present value of total costs is RM 29,651. By subtracting, we evaluate the NPV for oil palm cultivation at RM 135,293, and by calculating the ratio of these two values we obtain a BCR of 5.56. These values indicate that the overall performance of oil palm cultivation is such that this crop is profitable and an efficient investment.

The IRR was calculated by successive approximation (NPV=58 when IRR=67% and -22 when IRR=68%, hence NPV=0 when IRR= [0.67+0.01(58/80)]). Thus the minimum rate of return that will be obtained from oil palm plantation is 67.72% and the IRR is almost 17 times the discount rate (i.e. the 4% market interest rate assumed), again indicating that oil palm cultivation is a worthwhile investment.

Sensitivity analysis

We first examine the effects on the financial indicators of 10% changes, in the pessimistic direction, in the market selling price of FFB and in the costs of cultivation (Table 6). Reducing the market selling price of FFB from RM 530 to RM 477 tonne^{-1} causes the discounted sum of total revenue to decline from RM 164,944 to RM 148,449, but it does not change the discounted sum of costs (RM 29,651). Thus, NPV (the net benefit to the farmer) is reduced from RM 135,293 to RM 118,789, or by 12.2% for a 10% reduction in selling price. The BCR is correspondingly reduced from 5.56 to 5.01, and IRR falls from 67.72% to 63.22%. Increasing the costs of planting materials and labour for harvesting and transport (only) by 10% increases the discounted total cost from RM 29,651 to RM 31,284, reducing the NPV to RM 133,660 (by 1.2%). If, instead, we increase all costs by 10%, the discounted total cost rises to RM 32,616, NPV falls to RM 132,328 and BCR to 5.06. Thus, the financial indicators are more sensitive to a 10% reduction in the market price of FFB than to the same proportional increase in costs.

Figure 3 summarises the results of a more comprehensive sensitivity analysis. The left-hand

Table 5. Cashflow for a one-hectare plantation of 160 oil palm, with interest rates 4% (the current market interest rate).

				YEAR										
	unit	**RM/unit**	**unit**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
REVENUE														
Fresh Fruit Bunches	tonne	530		0	0	0	17	20	24	26	28	27	25	25
Total Revenue (TR)				0	0	0	9010	10600	12720	13780	14840	14310	13250	13250
TR discounted at 0.04 (4%)				0	0	0	7701.7858	8712.4273	10052.801	10471.667	10843.443	10054.016	8951.2252	8606.9473
COSTS														
Land Preparation														
Felling and clearing	ha	1300	1	1300										
Drainage				309										
Roads				500										
Lining				70										
Holing and planting				600										
Sum				2779										
Input Costs														
Planting materials	palm	5	160	800	0	0	0	0	0	0	0	0	0	0
Fertilisers				120	270	360	380	380	400	400	400	400	400	400
Herbicide				210	220	200	60	50	50	40	40	40	40	40
Pesticide				70	70	70	50	50	40	40	40	40	40	40
Sum				1200	560	630	490	480	490	480	480	480	480	480
Labour Costs														
Fertilising				75	75	75	75	75	75	90	90	90	90	90
Pruning				0	0	31	31	31	31	31	31	31	31	31
Weeding				90	90	90	90	90	90	75	75	75	75	75
Harvesting	tonne	28		0	0	0	476	560	672	728	784	756	700	700
Transport	tonne	22		0	0	0	374	440	528	572	616	594	550	550
Sum				165	165	196	1046	1196	1396	1496	1596	1546	1446	1446
Total Costs (TC)				4144	725	826	1536	1676	1886	1976	2076	2026	1926	1926
Discounted TC				3985	670	734	1313	1378	1491	1502	1517	1423	1301	1251
PROFIT/Ha				-4144	-725	-826	7474	8924	10834	11804	12764	12284	11324	11324
Accumulated Profit					-4869	-5695	1779	10703	21537	33341	46105	58389	69713	81037
Discounted Profit				-3984.62	-670.30	-734.31	6388.81	7334.88	8562.27	8970.07	9326.53	8630.58	7650.09	7355.85

Table 5 (continuation)

	YEAR														
	12	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**Total**
REVENUE															
Fresh Fruit Bunches	26	28	26	26	26	26	26	24	24	24	22	22	20	20	532
Total Revenue (TR)	13780	14840	13780	13780	13780	13780	13780	12720	12720	12720	11660	11660	10600	10600	281960
TR discounted at 0.04	8606.9473	8912.5194	7957.6066	7651.5448	7357.2547	7074.2833	6802.1955	6037.4516	5805.242	5581.9634	4919.9998	4730.769	4135.2876	3976.2381	164944
COSTS															
Land Preparation															
Felling and clearing															
Drainage															
Roads															
Lining															
Holing and Planting															
Sum															
Input Costs															
Planting materials	0	0	0	0	0	0	0	0	0	0	0	0	0	0	800
Fertilisers	400	400	400	400	400	400	400	400	400	400	400	400	400	400	9510
Herbicide	40	40	40	40	40	40	40	40	40	40	40	40	40	40	1550
Pesticide	40	40	40	40	40	40	40	40	40	40	40	40	40	40	1110
Sum	480	480	480	480	480	480	480	480	480	480	480	480	480	480	12970
Labour Costs															
Fertilising	90	90	90	90	90	90	90	90	90	90	90	90	90	90	2160
Pruning	31	31	31	31	31	31	31	31	31	31	31	31	31	31	713
Weeding	75	75	75	75	75	75	75	75	75	75	75	75	75	75	1965
Harvesting	728	784	728	728	728	728	728	672	672	672	616	616	560	560	14896
Transport	572	616	572	572	572	572	572	528	528	528	484	484	440	440	11704
Sum	1496	1596	1496	1496	1496	1496	1496	1396	1396	1396	1296	1296	1196	1196	31438
Total Costs (TC)	1976	2076	1976	1976	1976	1976	1976	1876	1876	1876	1776	1776	1676	1676	47187
Discounted TC	1234	1247	1141	1097	1055	1014	975	890	856	823	749	721	654	629	29651
PROFIT/Ha	11804	12764	11804	11804	11804	11804	11804	10844	10844	10844	9884	9884	8924	8924	234773
Accumulated Profit	92841	105605	117409	129213	141017	152821	164625	175469	186313	197157	207041	216925	225849	234773	
Discounted Profit	7372.74	7665.73	6816.52	6554.34	6302.25	6059.86	5826.79	5147.02	4949.06	4758.71	4170.61	4010.20	3481.44	3347.54	135293

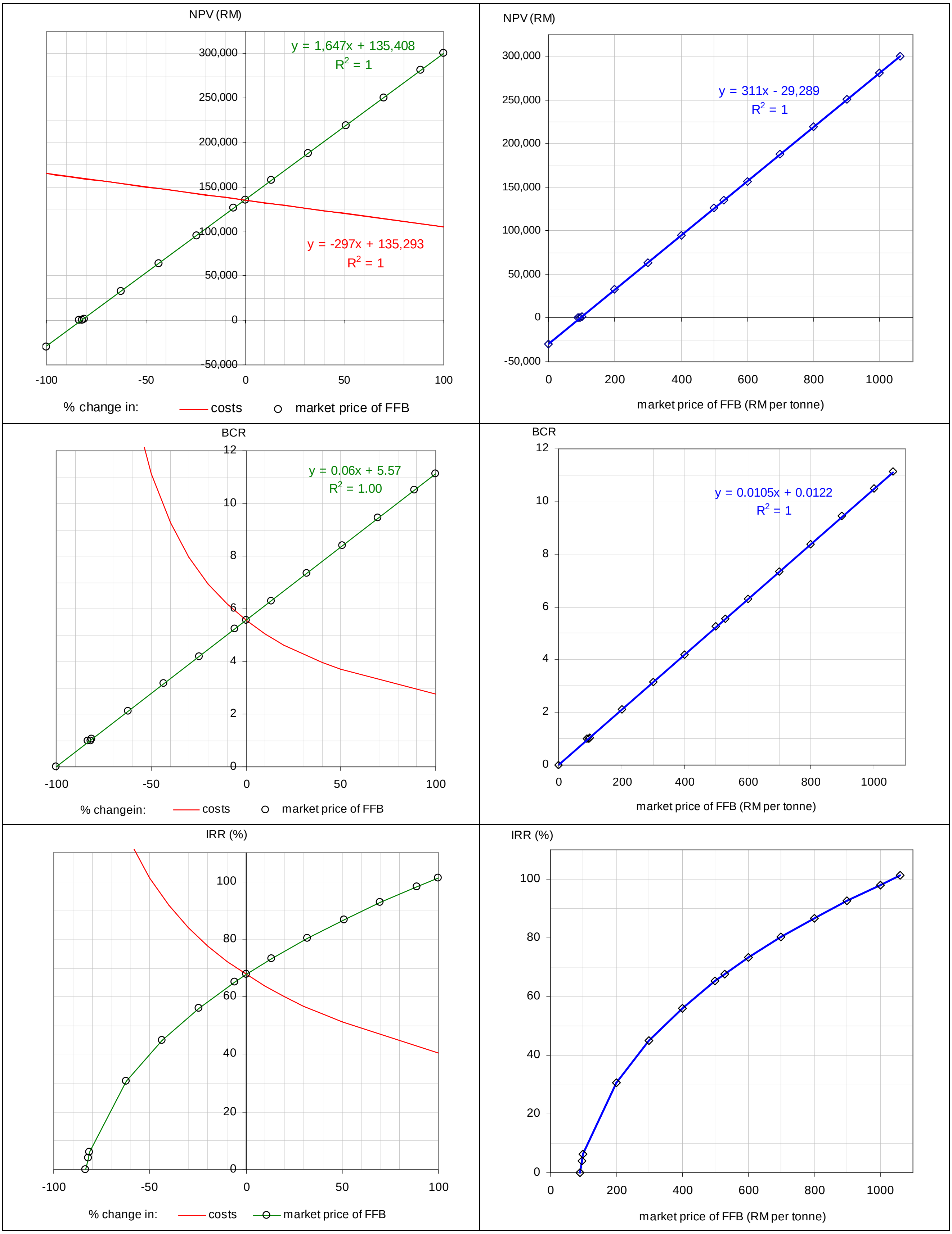


Figure 3. Sensitivity analysis, showing how NPV, BCR and IRR vary with % change in total costs and FFB price (left-hand column) and with the absolute market price of FFB (right-hand column). Trend lines have been fitted where linear relationships exist. In each case, all variables apart from the one being manipulated are as in Table 5, i.e. interest rate 4%, FFB market price RM 530 and discounted total costs RM 29,651.

column shows the effects on the three financial indicators of proportional changes of -100% to +100% in the FFB market price and in total production costs; whilst the right-hand column illustrates the sensitivity of the financial indicators to the actual market selling price of FFB in RM. For NPV, the relationships are linear. The left-hand graph shows that a 1% change in the FFB market price will alter NPV by RM 1,649 whereas the effect of a 1% change in costs is reflected by a change of only RM 297 in NPV. In the right-hand graph, the intercept on the (negative) y-axis corresponds to the total discounted cost of the project (RM 29,651), which would be the project's NPV in the absence of income from sales. NPV increases by RM 31,100 for every RM 100 $tonne^{-1}$ increase in the market price of FFB, with the project just breaking even when the market price reaches RM 95 $tonne^{-1}$. BCR is also linearly related to the market price of FFB, such that its value changes by 1.05 for every RM 100 $tonne^{-1}$ change in market price. In terms of proportional changes, doubling costs or halving market price reduces BCR from 5.56 to *ca*. 3 and IRR from 67.7% to *ca*. 40%; whereas halving costs or doubling market price will increase BCR to 11.1 and IRR to 101%. The market price must fall to RM 95.3 $tonne^{-1}$ to reduce the IRR to 4%, and RM 88.7 $tonne^{-1}$ to reduce it to zero.

Figure 4 explores the sensitivity of NPV and BCR to interest rate. Changing the interest rate from 4% to 10% reduces the NPV from RM 135,293 to 66,649 and the BCR from 5.56 to 4.83.

Table 6. Sensitivity of NPV, BCR and IRR derived from the standard scenario explored in Table 5 (Column b) to pessimistic changes of 10% in the market price of oil palm FFB (Column a) and in production costs (Columns c, d).

	a	b	c	d
Financial indicator	10% reduction in market price to RM 477 $tonne^{-1}$ FFB	Standard scenario (Table 5)	Input and labour costs increased by 10%	All costs increased by 10%
NPV (4%) (RM)	118,798	135,293	133,660	132,328
BCR	5.01	5.56	5.27	5.06
IRR	63.22%	67.72%	66.72%	63.64%

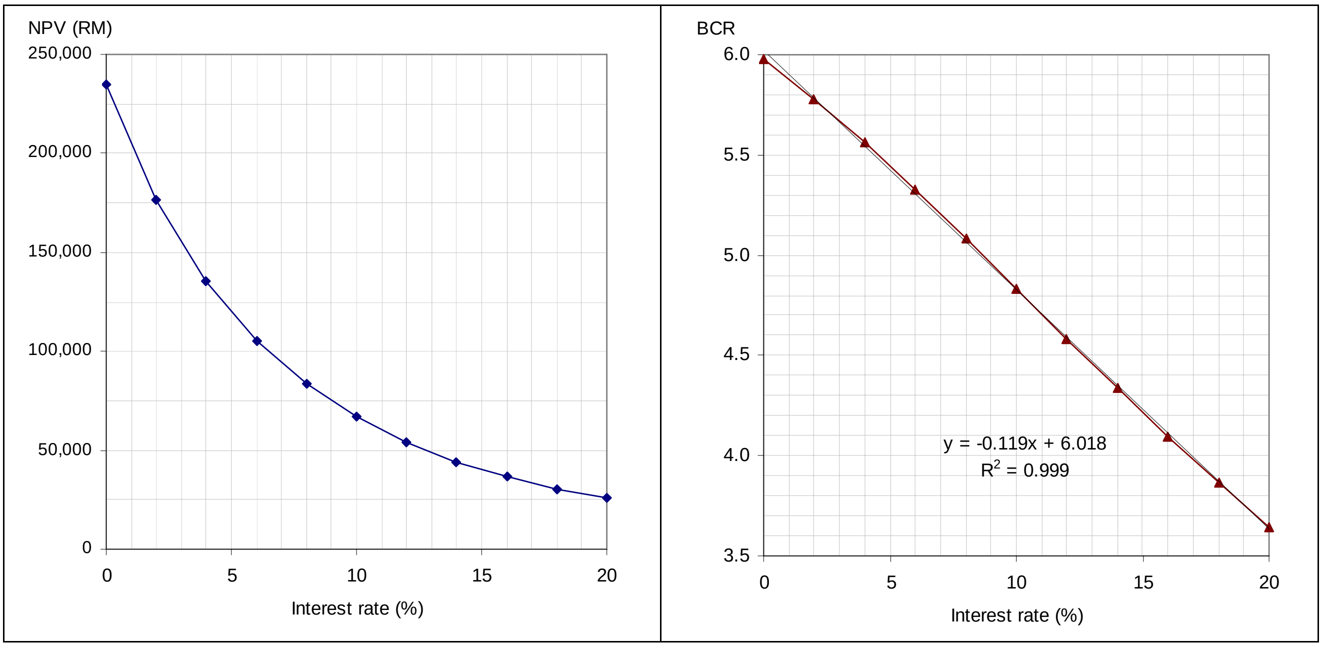


Figure 4. Variation of (left) NPV and (right) BCR with interest rate.

DISCUSSION

Our application of the Cobb-Douglas model is novel in the developing field of peatland forestry economics. However, it explained only *ca*. 39% of the total variation in our data. We conclude that our study did not take account of all of the factors which affect the output *Q*. Nonetheless, the results are helpful in that they indicate decreasing returns to scale, and that revenue from oil palm cultivation in Sungai Panjang (the output) is influenced much more by chemical than by labour inputs. Thus, there is a potential role for government in assisting farmers to optimise their use of chemicals.

The financial assessments indicate that oil palm cultivation is commercially viable and a profitable investment for private farmers in Sungai Panjang. In the standard scenario adopted as the basis for the calculations of financial indicators (Table 5), the NPV is well above zero and the BCR of 5.56 implies a substantial return per unit cost which compares favourably with other crops, and which is attainable due to the low maintenance costs of oil palm plantation. The IRR (*ca*. 68%) is almost 17 times the current market interest rate, and indicates a high rate of return which compares very favourably with the highest IRR value of 36% found in published literature (Bacha & Rodriquez 2007). Moreover, the sensitivity analyses indicate that oil palm cultivation is fairly robust as an investment, in that an IRR of 40% can still be attained if the market selling price of FFB is halved or if production costs are doubled, and doubling of the long-term interest rate (to 8%) would reduce the NPV by only *ca*. one-third.

Absolute income may, however, be more important than financial performance for a private farmer whose living depends entirely on oil palm cultivation. The annual income data collected during this study (Table 1) are broadly similar to the those reported by Jenkins & Haughton (1980) for single cropping padi farmers in peninsular Malaysia (mean annual income US$ 2,230, median US$ 1,571); although the dollar exchange rate may well have changed substantially since the time of that study, and inflation has surely occurred. The scenario presented in Table 5 yields an average discounted monthly income of RM 753 (RM 9036 p.a.) from 1 ha of oil palm plantation over 25 years. Whilst this is less than one-quarter of the 2007 average monthly income per Malaysian household (RM 3,686), it is close to recent estimates of the (apparently hardly adequate) budget that remains for food (RM 775–800) for a family of four in a Malaysian city, after their largely city-related fixed expenses have been met (Loone 2006, Lau 2008). Information about South Asian farmers' finances is notoriously difficult to obtain (Changchui 2007), but if it can be assumed that rural prices are similar to those in cities, this is an income level at which changes of RM 100 tonne^{-1} in the FFB selling price (Figure 3), or of 1% in the long-term interest rate (Figure 4), could make a significant difference to the adequacy of farmers' household budgets.

Previous cost-benefit analyses of oil palm cultivation (e.g. Jusoh *et al*. 2003) have assumed a long-term interest rate of 10%, which may be a slightly pessimistic reflection of the real situation in recent decades. For example, during the period 1980–2005, the base lending rate (BLR) in Malaysia initially fluctuated between 12.25% (1984) and 6.81% (1994), but after 1999 declined towards a new minimum of 6.0% in 2005 (ONGKL 2008). Now, in early 2009, the market interest rate is still below 7% per annum, whilst long-term loans attract *ca*. 4% interest and car loans only 2.75%. The interest rate of 4% used in our study was chosen to reflect the current situation, but we cannot be sure how this will change during the next 25-year rotation of oil palm. It may be helpful to construct a comparative hindcasting study, in which actual historical interest rates and FFB prices are applied to our oil palm yield data.

One of the main constraints on farming in Sungai Panjang is the limited areas of land that individual farmers own, which means that most of them plant just one crop. Given the income levels of many of the farmers interviewed during our study, a particular drawback of oil palm cultivation would appear to be the extremely high establishment costs during the first year. This may be unattainable for some potential cultivators, especially when combined with the total lack of revenue during Years 1–3 (Table 5). Nonetheless, many do choose oil palm because it provides a slightly better income than fruit and vegetables. On the other hand, they seldom exploit the potential for maximising usage of the peatland by intercropping with, for example, pineapple during the early 'zero-revenue' years after planting oil palm. Most of them are even unaware of the additional income available to them from selling parts of the trees other than FFB, such as loose fruits and fronds, which are valuable livestock foods. This renders them vulnerable to exploitation by buyers and other outsiders. Thus, in order to help maximise farming incomes, our work indicates a need for intervention by the government's Agricultural Department to set market prices for, and encourage the sale of, more parts of the oil palm trees; and for extension services to encourage intercropping.

It was originally our intention to explore not only the strictly financial aspects of oil palm cultivation, but also some related environmental issues, including peat subsidence (Hutchinson 1980), loss of peatland functions and river quality (see Appendix). Such considerations are relevant to determining whether oil palm cultivation can be sustained and meet our needs indefinitely, especially without compromising the ability of future generations to meet their own needs (Brundtland Commission 1987). This part of the work was limited by the inadequacy of available data on externalities, as well as by lack of knowledge amongst the farmers; and its extension is a general aim for future studies. The next steps, however, should involve both prospective and retrospective ordinary and extended Cost-Benefit Analysis (CBA) of oil palm cultivation in the private and public sectors. Also, larger sample sizes encompassing more locations or estates would enable us to extrapolate our findings to the whole of Malaysia.

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Appendix. The questionnaire used during interviews with oil palm farmers.

I. ATTITUDE TOWARDS PEATLAND AND ITS USE		
The aims of this section are: i) to discover how you value peat in general; and ii) to gauge your preferences in relation to how the use of peatland for agriculture should be conserved. I will ask you to value an environmental change at the end of this section.		
The peatswamp forest (PSF) has many ecological functions in its natural state. Among these are flood mitigation, recreation and carbon sequestration. The conversion of land, e.g. for agriculture, will reduce these functions. In light of this there is a concern on the clearing of PSF for agricultural use because of many of these functions are lost. The peatland area in Peninsular Malaysia is about 32% of total peat area. Carbon sequestration function is one of the major functions. When there is more carbon dioxide in the atmosphere this can result in a warmer temperature. When PSF is cleared, the only way to sequester carbon is in the soil.		
1	How close is the nearest peat soil to you?	<1 km 1–2 km >2 km
2	How often to you pass or have contact with peat?	continually occasionally seldom
3	Do you own any land on peat?	Yes No
4	In your opinion, should the peatland in this area be used mainly for agriculture?	Strongly agree Agree Hardly agree Don't agree
5	Are you aware that agricultural activities on peatland can affect the quality of the environment?	Yes No Don't know
6	Do you think conservational use of peatland should be adopted?	Yes No Don't know
7	How important it is to manage the peatland?	Very important Important Not very important Not at all important Don't know
8	We should preserve the use of peatland so that our grandchildren can use it later?	Strongly agree Agree Hardly agree Disagree Don't know
WTP Question The practice of slash and burn has been used in palm oil cultivation in this area. Burning of residue will result in the soil releasing carbon dioxide into the atmosphere. This will cause pollution and also the rise in temperature because of the concentration of carbon dioxide in the atmosphere. Zero burning technique (ZBT) is recommended for farming as this will help in mitigating the release of carbon. Soil can store carbon if proper management technique is employed and with this you can enjoy a better environment. This is also for the benefit of the next generation where they can enjoy a cleaner environment. This is an effort that we can take in an ensuring that you can have a better environmental quality. If you understand what is explained above take a moment to think as you will be asked to give a value shortly.		
9	Are you willing to pay RM 4 to have a better environment using this approach?	(Yes / No)
10	[if the answer to Q9 was 'no'] Are you willing to pay RM2?	(Yes / No)
11	[if the answer to Q9 was 'yes'] Are you willing to pay RM6?	(Yes / No)
12	[if the answer to Q11 was 'yes'] What is the maximum amount you are willing to pay?	

II. THE VALUE OF WATER QUALITY		
This section is to know your view on the river and to elicit how you value the water quality in this area.		
1	Do you have any interest in the river?	(Yes / No)
2	Do you use any of the rivers? [If 'yes' give name of river]	
3	If you DO use the river, what do you use it for?	Fishing Transportation Bathing Washing
4	How would you describe the cleanliness of the river?	Very clean Clean Not clean
5	How important is it for the river to be clean?	Very important Important Not very important Not at all important Don't know
6	We need to protect the river?	Strongly agree Agree Hardly agree Disagree Don't know
7	The government should play the role in increasing the quality of the river?	Yes No (explain why)
8	If the government implement a policy to increase the quality of the river and use the public fund, do you agree to this?	Yes No (explain why)
WTP Question Runoff from agricultural activities can influence the quality of water and there are measures that will minimise this negative impact. Nevertheless these kinds of measures will require some amount of money to be implemented.		
9	Are you willing to pay RM 4 to protect the river?	(Yes/ No)
10	[If No] Are you willing to pay RM 2?	(Yes/ No)
11	[If Yes to 9] Are you willing to pay RM 6?	(Yes/ No)
12	[If Yes to 11] What is the maximum amount you are willing to pay?	

III. INFORMATION ON OIL PALM CULTIVATION		
1	Do you own a palm oil farm?	(Yes/ No)
2	What is the size of your farm in acres? (1 ha = 2.47 ha)	
3	Planting rate? (trees per acre)	
4	What is your average output per acre? (in tonne)	
5	What is the price of fresh fruit bunch (FFB) per tonne? (in RM)	
6	In your estimate how much do you earn from oil palm farming per year? (in RM)	
7	What is the specific use of each of these parts of the oil palm tree? Please state:	Leaves Trunk Frond Shell Empty fruit bunch Others
8	Do you get any output other than oil palm?	(Yes / No)
	[If Yes] Please state from which of the following:	Leaves Trunk Frond Shell Empty fruit bunch Fish from the river, RM Others (please state), RM

9	How much do you spend per year for the following inputs (RM ha^{-1})	Fertiliser Pesticide Herbicide Labour Other (state)
10	Is your family involved in the farm?	(Yes/ No)
11	Why are you involved in oil palm cultivation?	Easy to manage good Family tradition Agricultural Dept. Scheme No other choice Other reasons
12	How often do you consume any palm oil?	Every 2–3 days Once a week Once a month Very rarely
13	Oil palm farming is important to the people here?	Strongly agree Agree Hardly agree Disagree Don't know
14	Do you think that oil palm cultivation should be continued? Please give reasons for your answer.	(Yes/No)

IV. PERSONAL INFORMATION OF RESPONDANTS		
1	Gender	(Male / Female)
2	Age	
3	Marital status	Single Married Widowed Divorced or separated
4	Number of persons in household	
5	Job	
6	Which of the following reflects your income level per year?	<RM1,000 RM1,001–5,000 RM5,001–10,000 RM10,001–15,000 RM15,001–20,000 RM20,001–25,000 RM25,001–30,000 >RM30,000
7	What is the highest formal education you achieved?	No formal schooling Primary school Form 3 Form 5 Diploma Degree or higher
8	How long have you lived in Sungai Panjang?	<6 months 6 months–1 year 1–3 years 3–5 years 5–10 years >10 years